REMARKS/ARGUMENTS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-37 are pending in the present application with claims 1, 24 and 34 having been amended by the present amendment.

In the outstanding Office Action, claims 1-3, 24, 25, 34 and 37 were rejected under 35 U.S.C. § 103(a) as unpatentable over Bordsen et al.; and claims 4-24 and 26-37 were rejected under 35 U.S.C. § 103(a) as unpatentable over Bordsen et al. in view of Bohannon et al.

Applicants note an Information Disclosure Statement (IDS) was filed on March 30, 2004. Accordingly, it is respectfully requested the Examiner acknowledge the consideration of the reference cited therein by issuing an acknowledged PTO-1449 form.

Claims 1-3, 24, 25, 34 and 37 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Bordsen et al. This rejection is respectfully traversed.

Amended independent claim 1 has been amended to recite that the logging method includes generating a differential log record using $\Delta_t = b_{t-1} \oplus b_t$ where Δ_t is the differential log record generated for the t-th update on a database object b, $\oplus$ is the bit-wise exclusive-OR (XOR) operation, b_{t-1} is the image of the database before the t-th update occurs, and b_t is

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the image of the database after the t-th update occurs. Claim 1 has also been amended to recite that the recovery method includes redoing updates of committed transactions using

$$b_{s+p} = b_s \oplus \Delta_{(1)} \oplus \Delta_{(2)} \ldots \oplus \Delta_{(p)},$$ where b_s is the image of a database object b after s number of updates are reflected, b_{s+p} is the image of b rolled forward from b_s by p number of updates involved in committed transactions, where the sequence of the differential log records applied, $\Delta_{(1)}$ through $\Delta_{(p)}$, is any possible arrangement of the set of sequentially-generated differential log records $\{\Delta_{s+1}, \ldots, \Delta_{s+p-1}, \Delta_{s+p}\}$ in the order independent from the order of log creation, and includes undoing updates of uncommitted transactions using $b_{s-q} = b_s \oplus \Delta_{(1)} \oplus \Delta_{(2)} \ldots \oplus \Delta_{(q)},$ where b_s is the image of a database object b after s number of updates are reflected, b_{s-q} is the image of b rolled backward from b_s by q number of updates involved in uncommitted transactions, wherein the sequence of the differential log records applied, $\Delta_{(1)}$ through $\Delta_{(q)}$, is any possible arrangement of the set of sequentially-generated differential log records $\{\Delta_{s-q+1}, \Delta_{s-q+2}, \ldots, \Delta_s \}$ in the order independent from the order of log creation. Amended independent claims 24 and 34 include similar features in a varying scope.

On the contrary, in Bordsen et al., the before image is stored for use in the undo operation. Note, the present invention does not store the before image because the before

image is reconstructed from the differential log records. There are advantages resulting from not storing the before image as follows.

A first advantage of not storing the before image is space efficiency. In the present invention, the XOR-based differential log records are stored in a non-volatile storage, resulting in space efficiency. However, in Bordsen et al., both the audit records and the before images are stored in a nonvolatile storage, as recited in col. 5, lines 48-50.

A second advantage is a reduced Input/Output (I/O) burden. In Bordsen et al., additional I/O operations are required to store the before image during a run time and to read the before image during a recovery time. On the contrary, the present invention requires less number of I/O operations because the before image is not stored separately.

A third advantage is the execution order between the undo and redo operations can be arbitrary, resulting in more efficiency. On the contrary, Bordsen et al. does not teach or suggest that redo operations are applied independently of log creation. Rather, in Bordsen et al., the before image is stored and retrieved for the undo operation. As explained above, this is different from the undo operation of the present invention where the before image is not stored, but reconstructed from applying differential log records in an arbitrary order. Bordsen et al. further differs from the present invention in that the redo operations are applied in the order independent of log creations.

Bordsen et al. also does not teach or suggest that the execution order between the undo operations and the redo operations is arbitrary. On the contrary, according to the present invention, the differential logging enables the execution order between the undo operations and the redo operations to be arbitrarily intermixed. However, in Bordsen et al., only the sequence 1 in the example of Theorem 3 results in the correct database state, because the undo operation is performed by overwriting the current database state with the before image.

Accordingly, in light of the above comments, it is respectfully submitted independent claims 1, 24 and 34 and each of the claims depending therefrom patentably define over Bordsen et al. Further, it is respectfully submitted the other rejection in the Office Action has also been overcome as Bohannon et al. also does not teach or suggest the claimed features.

In addition, the first section of the Detailed Description of the Invention has been amended to include features of the invention that are recited throughout the specification. Applicants submit this additional information is supported by other sections discussed in the specification, such as the sections discussed with respect to Figures 5, 6C and 6E, for example. Applicants submit no new matter has been added.

CONCLUSION

In view of the foregoing amendments and remarks, it is respectfully submitted that

the application is in condition for allowance. Favorable consideration and prompt allowance

are earnestly solicited. If the Examiner believes that any additional changes would place the

application in better condition for allowance, the Examiner is invited to contact the

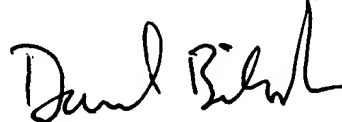undersigned attorney, **David A. Bilodeau**, at the telephone number listed below.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is

hereby made. Please charge any shortage in fees due in connection with the filing of this,

concurrent and future replies, including extension of time fees, to Deposit Account 16-0607

and please credit any excess fees to such deposit account.

Respectfully submitted,
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